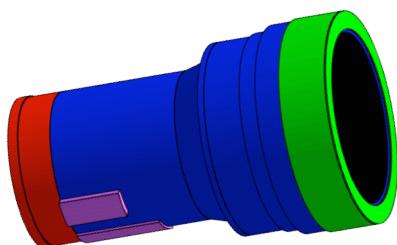
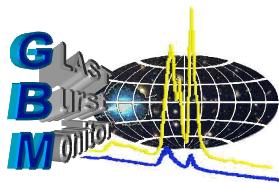


GBM Simulation and Instrument Response

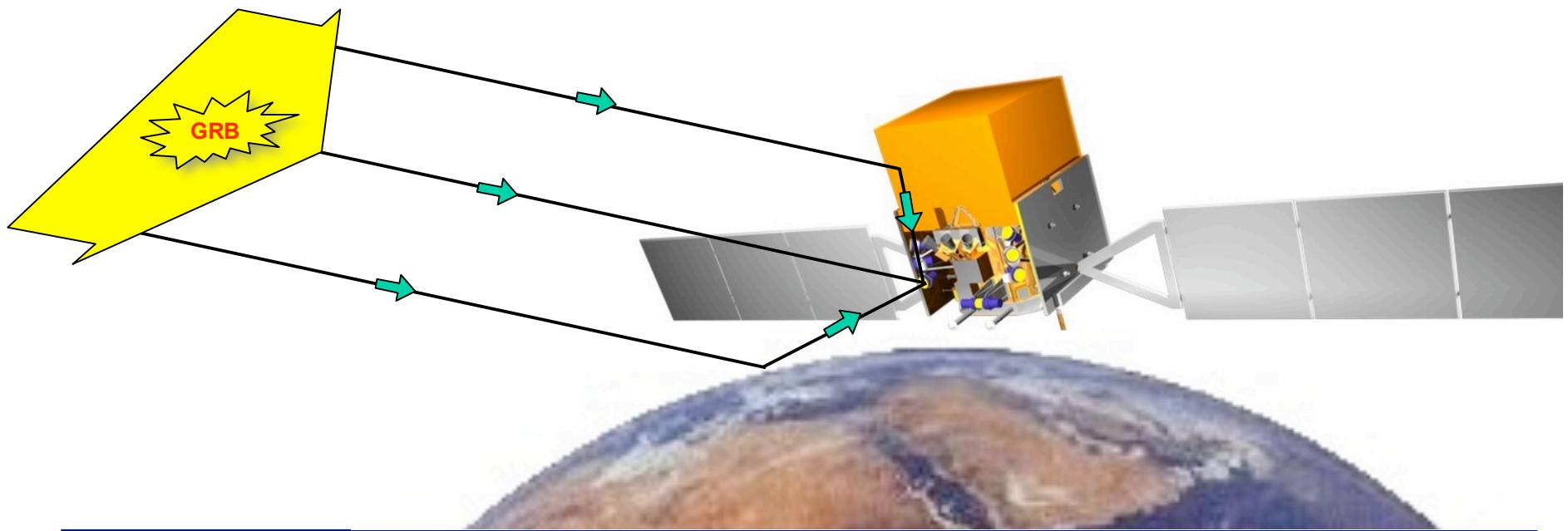
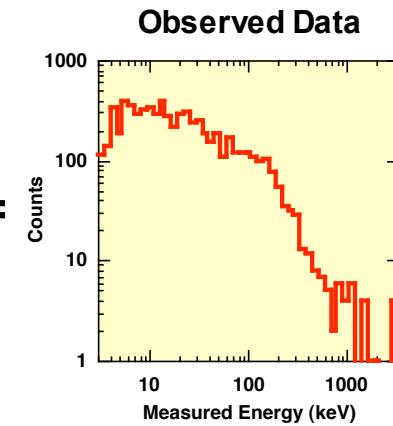
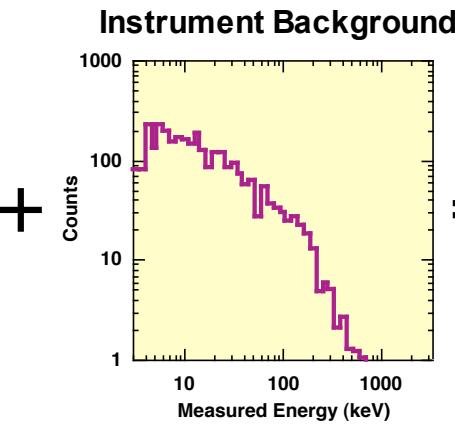
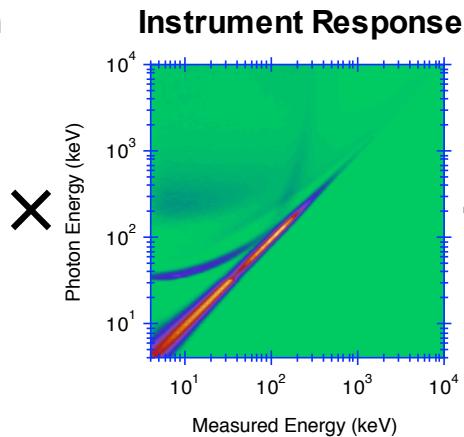
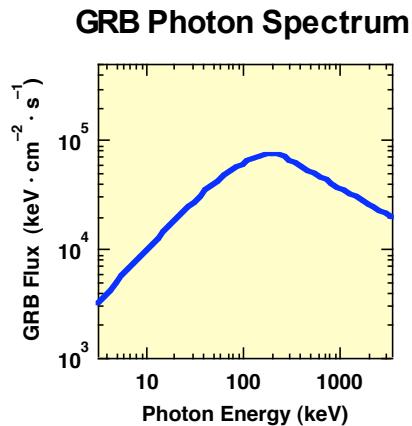


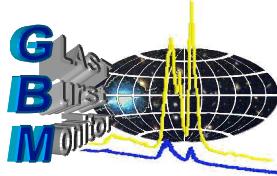
R. Marc Kippen

*Space and Atmospheric Sciences Group
Los Alamos National Laboratory*



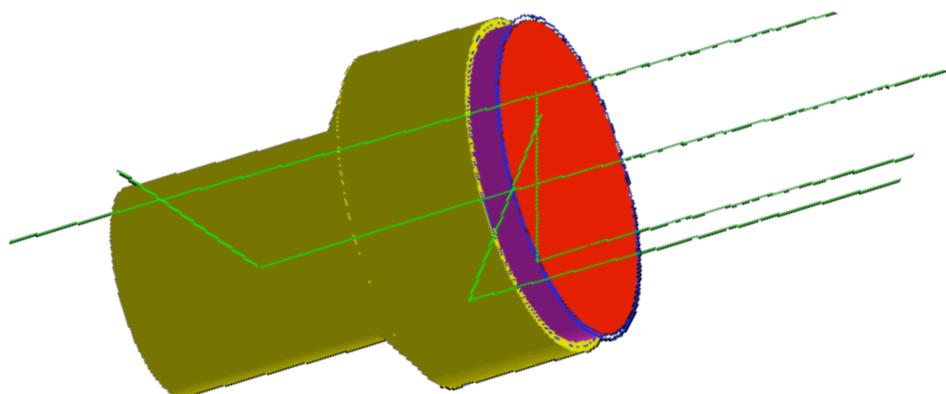
GBM Detector / Instrument Response





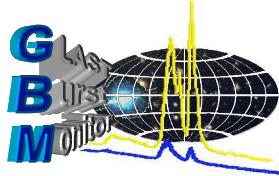
Simulation and Detector Response Software

- ❖ **Definition:** Multi-purpose software suite that computes the physical and instrumental response of the GBM instrument system
 - **Primary purpose:** generate *detector response functions* critical to the analysis of flight science data
 - **Other uses:** instrument design; interpretation of calibrations; design of flight and ground analysis algorithms & s/w
- ❖ **Technique:** Numerical simulation — Monte Carlo radiation transport
 - **Verified through, and incorporating results from experimental calibration**



Major Components

- ❖ Mass model (geometry + composition)
- ❖ Incident particle distributions
- ❖ Radiation transport physics
- ❖ Instrumental/calibration effects
- ❖ DRM database
- ❖ DRM synthesizer/generator



Key Functional Specifications

GBM SIM/DRM S/W Functional Specs

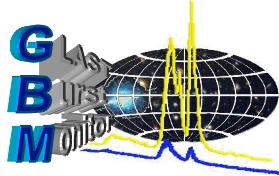
GBM-SPEC-1025 (reviewed at GSW PDR)

GBM IODA S/W Functional Specs

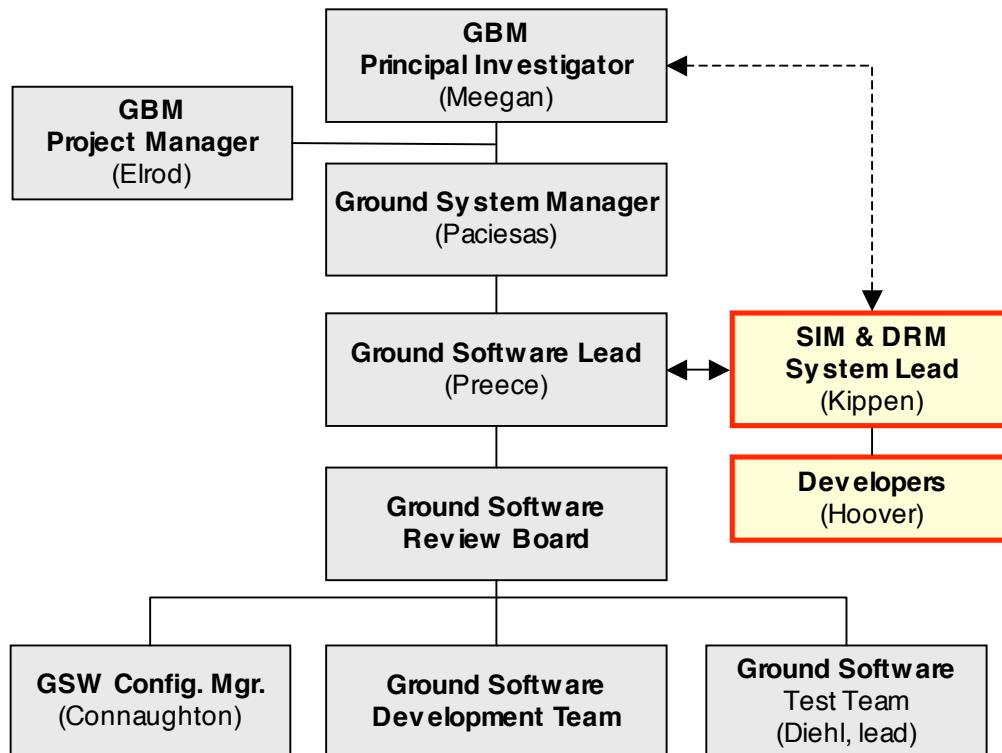
GBM-SPEC-1031 (reviewed at GSW PDR)

- ❖ Complete and accurate interaction physics (included in core simulation package — GEANT4)
- ❖ Accurate mass models, environment models, and instrument models (but not overly complex)
- ❖ Later stages of development require S/C models (including LAT model)

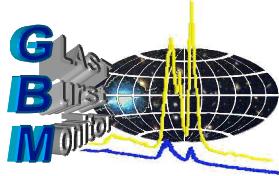
- ❖ Verification through comparison with experimental data
- ❖ Final DRMs must include contribution from atmospheric scattering (+direct detector and S/C scattered response)
- ❖ GLAST S/C will have rapid slew capability — different DRMs are required whenever aspect changes by $> 1^\circ$
- ❖ DRM generation s/w is part of GBM IODA s/w and subject to the same requirements for standards, configuration control, etc.



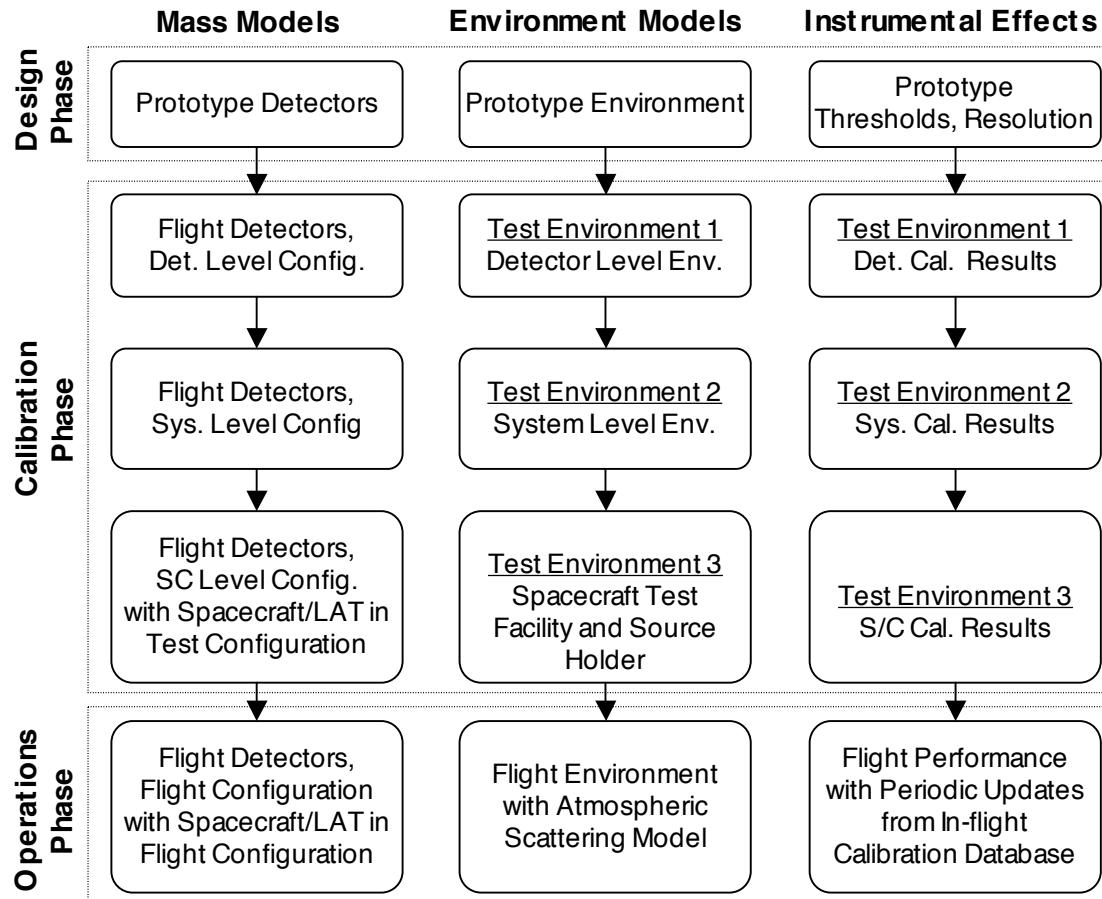
Development Organization



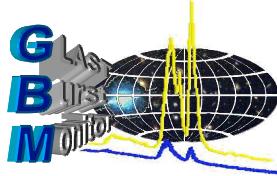
- **SIM/DRM software** designed and developed at LANL in collaboration with GBM PI and GSW lead
- Development process falls under GSW Development Plan (**GBM-PLAN-1023**)
- Final products (s/w and data) delivered to GBM PI at NSSTC (also available to MPE and other interested parties)



Phased Software/Model Development

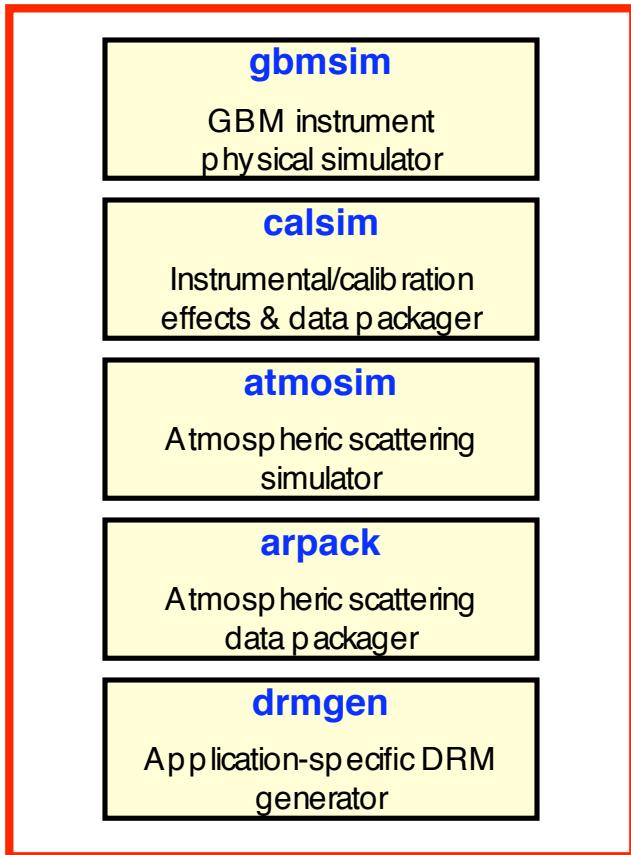


- ❖ Software and models require cross-validation with calibration data
- ❖ Three phases of SIM/DRM sw/model development
 - Design
 - ❖ Simulate prototype detectors
 - Calibration
 - ❖ Simulate three levels of calibration/test
 - Detector level
 - GBM system level
 - On-spacecraft level
 - Operation
 - ❖ In-flight configuration appropriate for analysis of science data
 - ❖ DRM generation

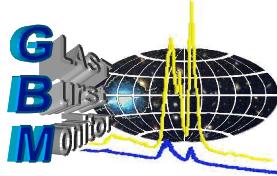


Implementation: GBM REsponse Simulation System

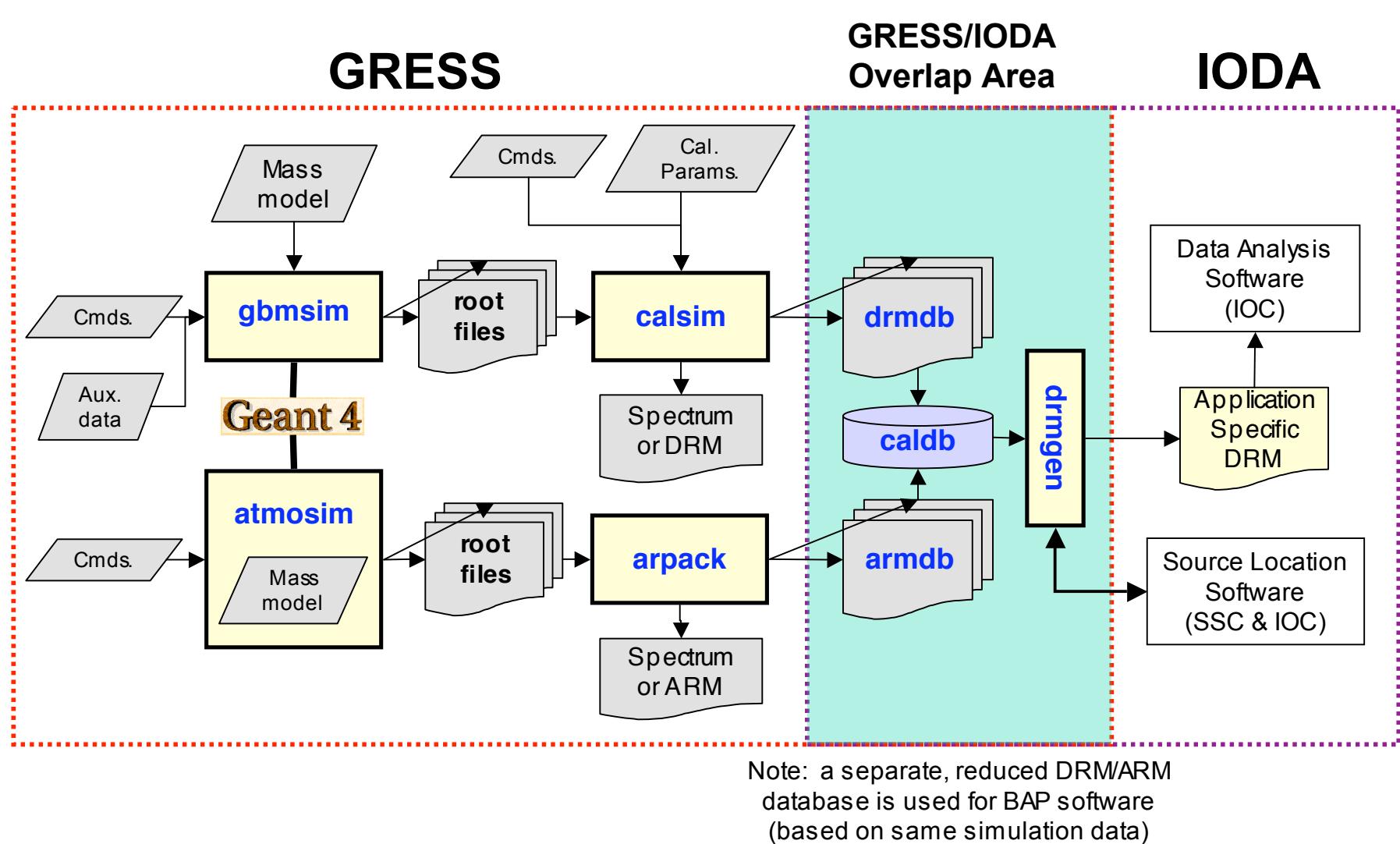
GRESS

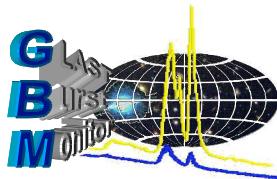


- ❖ Integrated package that will encompass all GBM instrument response software and data needs
- ❖ Configuration controlled as a single deliverable package with component software/data modules
- ❖ All packages (and their dependencies) use GNU compilers — mainly g++
- ❖ All data files have headers with detailed version & job tracking data
- ❖ Final phase package will be a subset of the GBM IODA software, cf. GBM-SPEC-1036 (GSW Arch. Design)



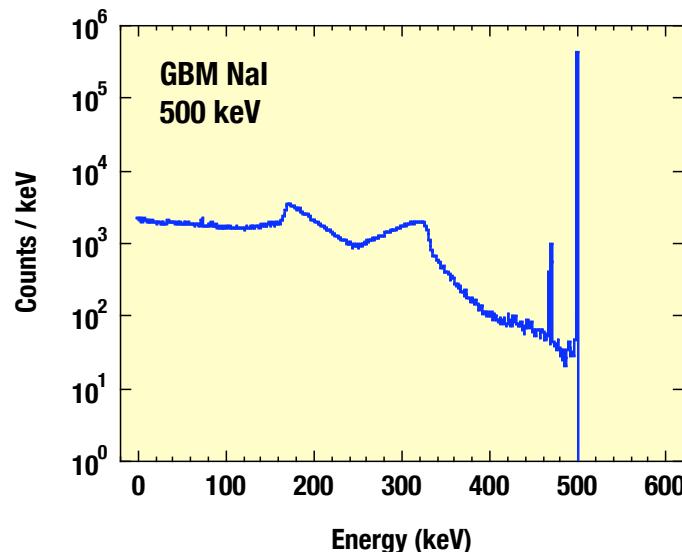
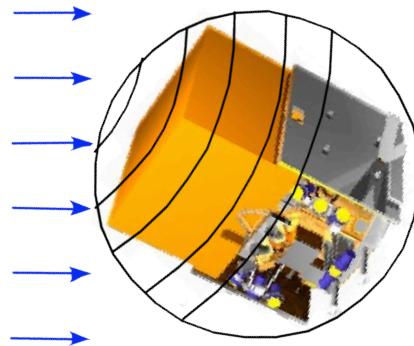
Implementation: GBM REsponse Simulation System





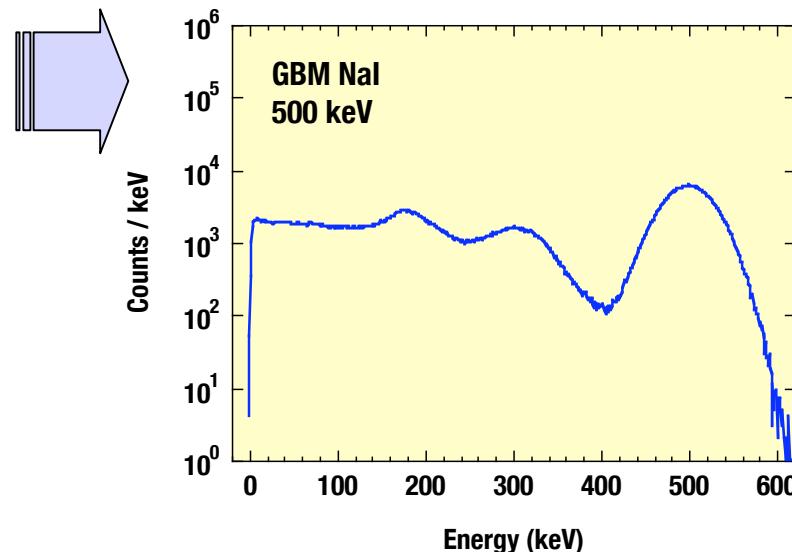
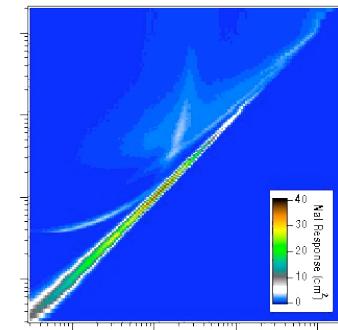
How – Direct Instrument Response

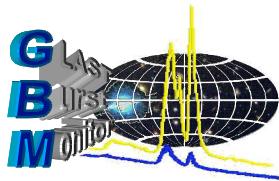
gbmsim — Raw “physical” data



calsim — Packaged, instrument-like data

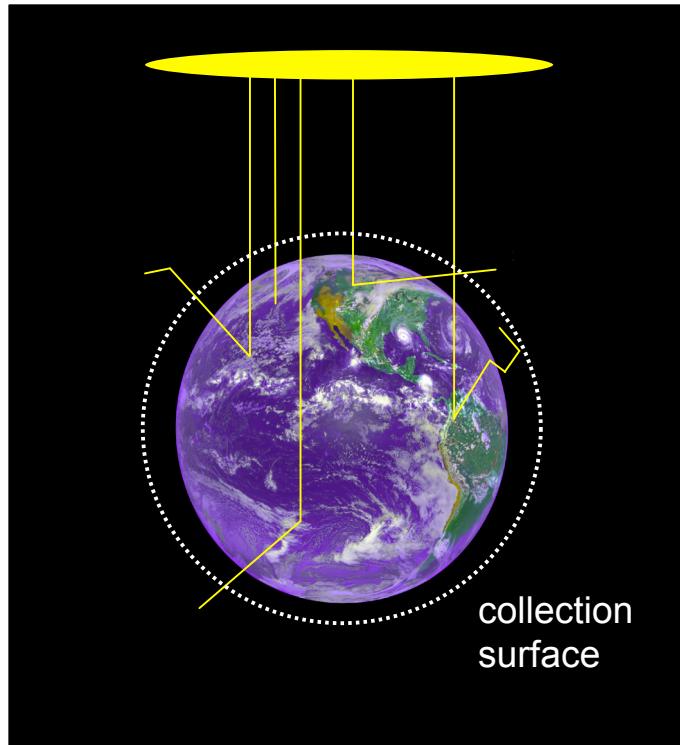
$$\Re_D(\vartheta, \varphi, E_\gamma, E_m)$$





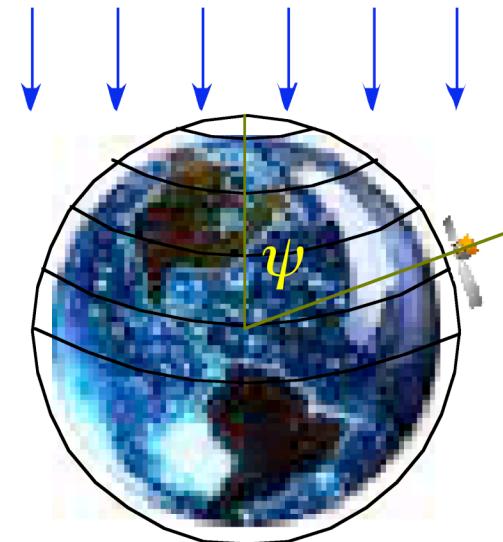
How – Atmospheric Scattered Response

atmosim — Raw “physical” data

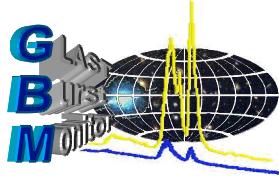


NRLMSISE-2000 atmospheric model used
to create concentric shell mass model

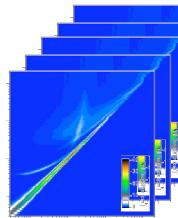
arpack — Packaged data matrix



$$\mathfrak{R}_A(\psi, A, \vartheta', \varphi', E_\gamma, E_s)$$

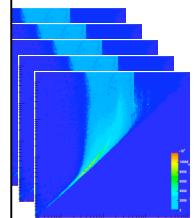


How — Putting it all Together



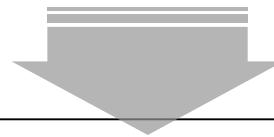
drmdb — direct response db

$$\Re_D(\vartheta, \varphi, E_\gamma, E_m)$$



armdb – Atmos. Resp. db

$$\Re_A(\psi, A, \vartheta', \varphi', E_\gamma, E_s)$$

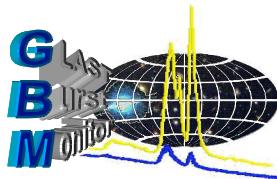


drmgen — burst-specific response generator

$$\Re_T(E_\gamma, Ch) = \Re_D(\vartheta_o, \varphi_o, E_\gamma, Ch) + \iint \Re_A(\psi_o, A_o, \vartheta', \varphi', E_\gamma, E_s) \cdot \Re_D(\vartheta', \varphi', E_\gamma, Ch) d\Omega'$$

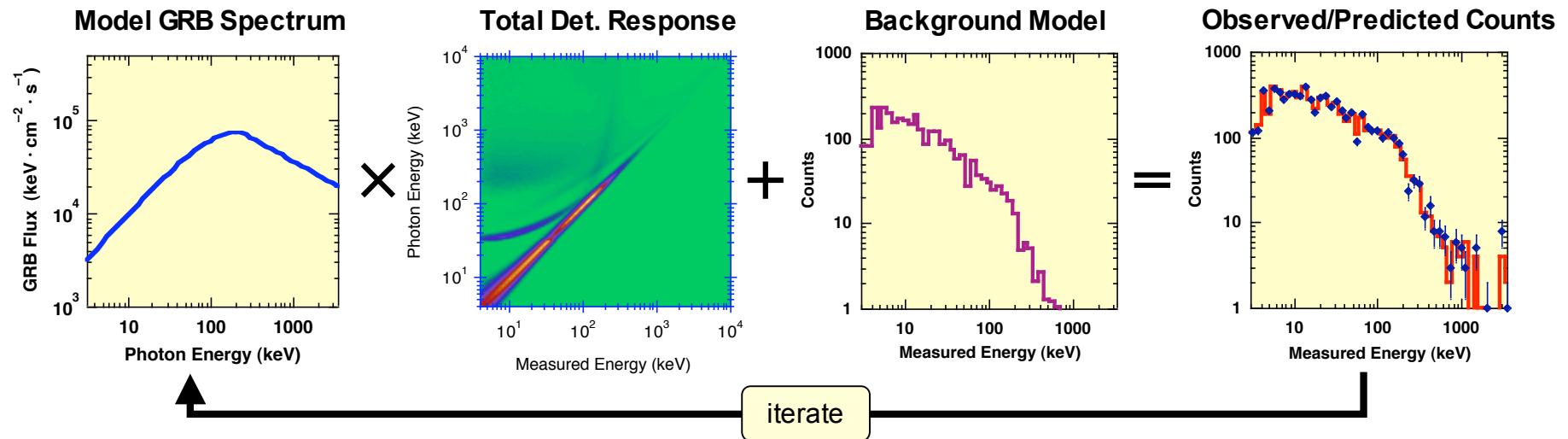
Data Analysis – spectral fitting and localization

$$C_i = \int f(E_\gamma) \cdot \Re_T(E_\gamma, Ch) dE_\gamma$$

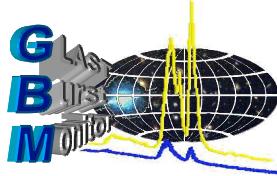


How — Response used for Spectral Analysis

rmfit/xspec — spectral model “hypothesis testing”

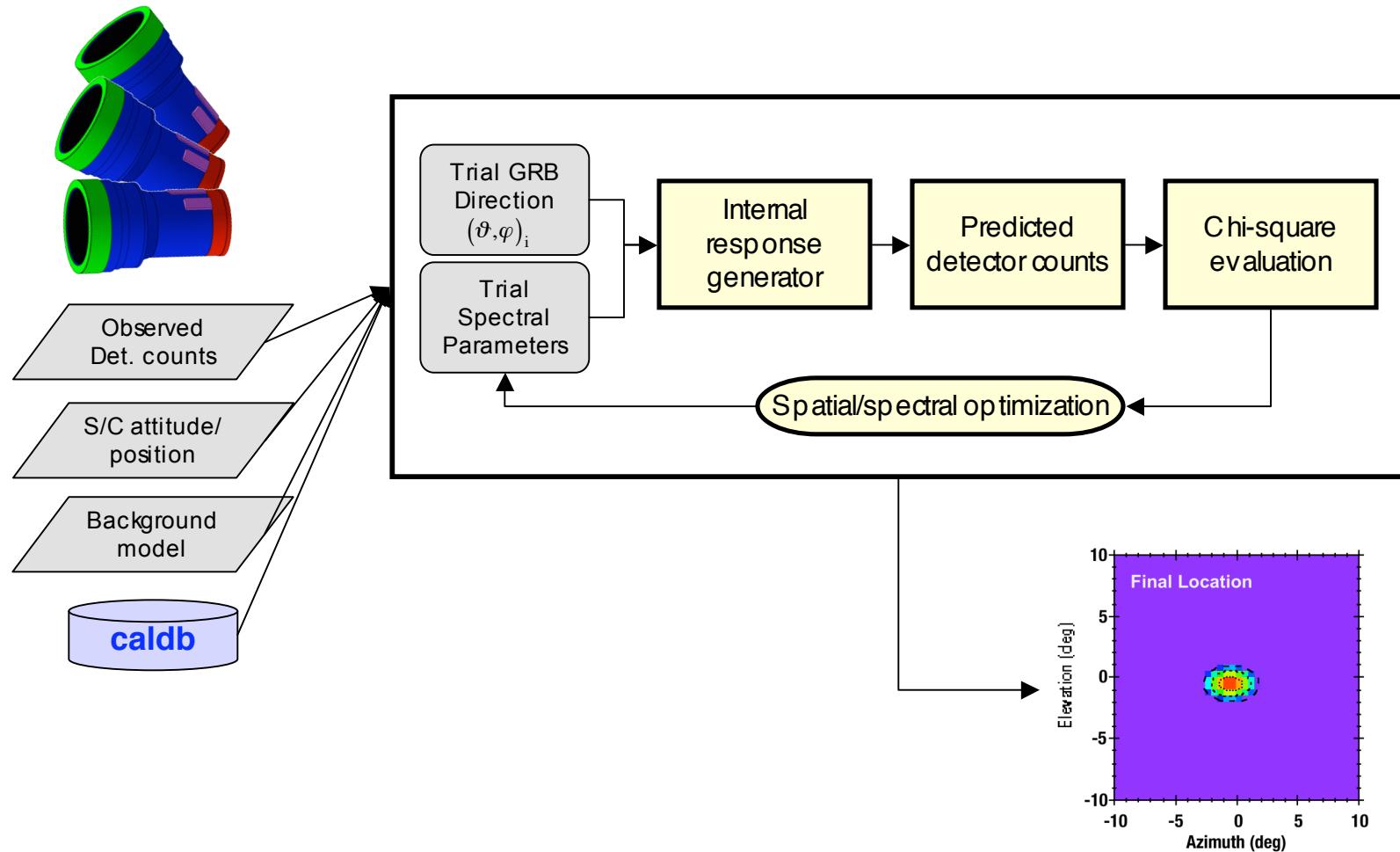


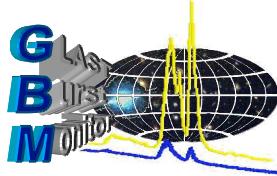
- Parameterized spectral models
 - Built-in models or “custom” models
 - From drmgen
 - Updated automatically when S/C pointing changes
 - Empirical, time-dependent model based on data before and after burst
 - Observed and predicted counts compared via test statistic
 - Chi-squared (Gaussian) or Poisson log Likelihood
 - Optimize test Stat. iteratively
- Process is extended to simultaneously include multiple GBM detectors (Incl. NaI and BGO) or other instruments (e.g., LAT, Swift, etc.)



How — Response used for Localization

Simultaneous spatial/spectral model “hypothesis testing”





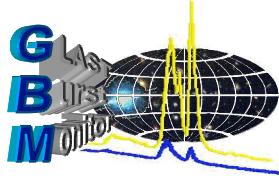
Development Status

❖ SIM/DRM development is affected by:

- **Delivery of GBM detector design data/drawings (received June 2004, three months behind original schedule)**
- **Delivery of GLAST spacecraft design data/drawings (expected July 2004, three months behind original schedule, initial delivery August 2004)**
- **Schedule of GBM calibrations**
 - ❖ Required to verify SIM/DRM s/w and models
 - ❖ Detector level (MPE), system level (NSSTC), spacecraft level (Spectrum) — all slipped due to launch slip.

❖ Development status:

- **Preliminary versions of GRESS software complete (several months ahead of schedule)**
- **Detector model development nearing completion (3 months behind)**
- **Spacecraft model development starting (3 months behind)**
- **Result: able to meet required delivery schedule**



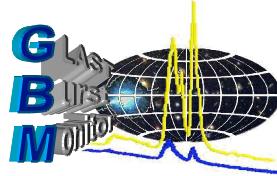
SIM/DRM Revised Delivery Schedule

Stable since GBM System CDR June 2004

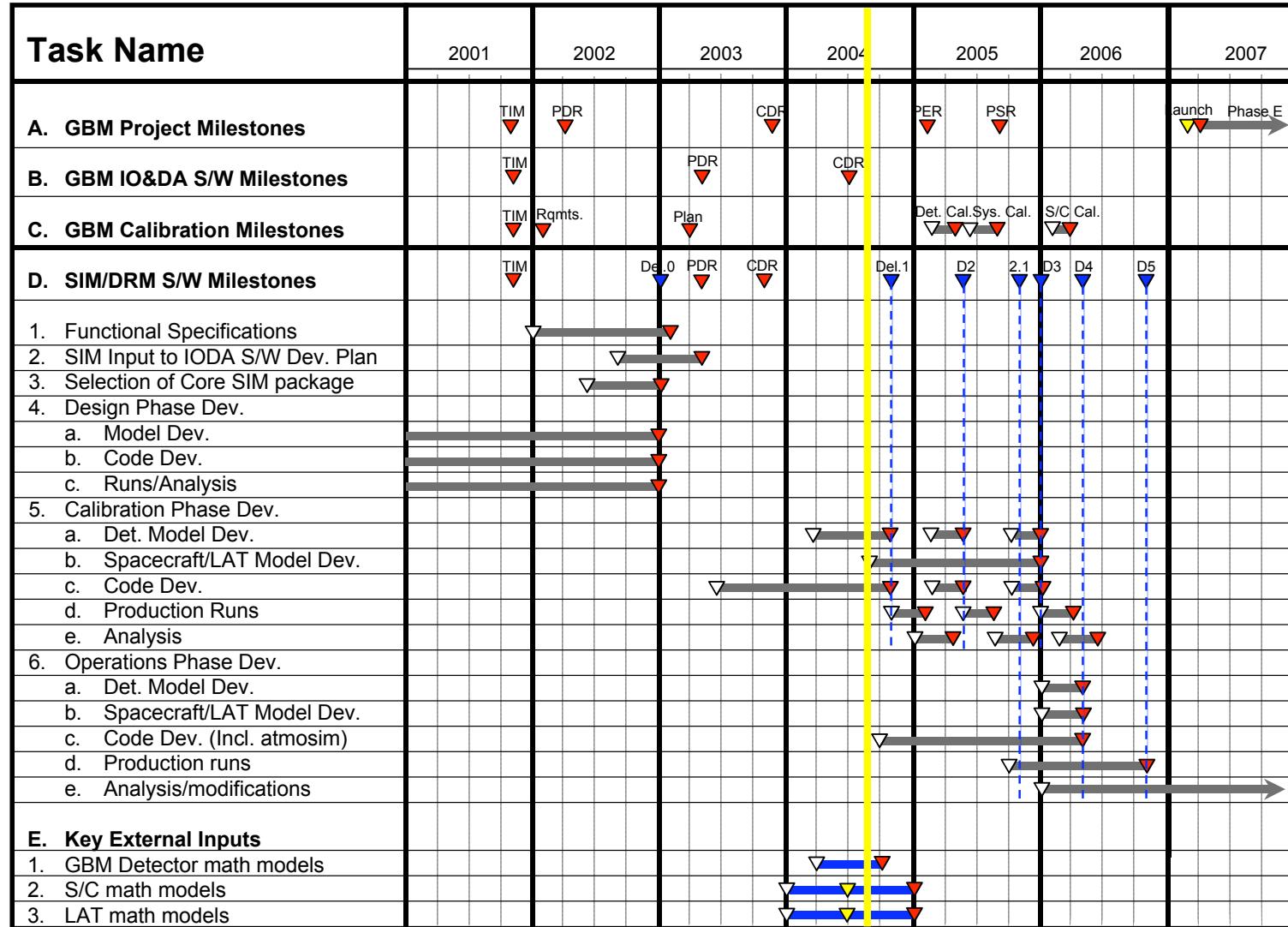
Milestone	Date [†]	Driver	Date
SIM/DRM Delivery 1 (Det.-level s/w & models)	Nov. 1, 2004 ($\Delta+4$ mo)	Verify s/w & models with GBM detector-level calibrations	Feb. 2005 – Mar. 2005
SIM/DRM Delivery 2 (Syst.-level s/w & models)	Jun. 15, 2005 ($\Delta+3$ mo)	Verify s/w & models with GBM system-level calibrations	Jul. 2005 – Sep. 2005
SIM/DRM Delivery 2.1 (preliminary CALDB/DRM)	Nov. 1, 2005 (new)	Support IODA Release 2.2 & 2.3, and Data Challenge 3	Nov. 1, 2005; Dec. 1, 2005
SIM/DRM Delivery 3 (S/C-level s/w & models)	Jan. 2, 2006 ($\Delta+3$ mo)	Verify s/w & models with GBM spacecraft-level source survey	Feb. 2006
SIM/DRM Delivery 4 (Ops. phase s/w & models)	Apr. 14, 2006 (no change)	Support IODA Release 3 (launch-ready software)	Sept. 1, 2005
SIM/DRM Delivery 5 (Final DRM/CALDB database)	Nov. 1, 2006 (no change)	Support Phase E science/Ops.	Post-launch

* All deliveries from LANL to NSSTC

[†] Schedule changes from ground s/w CDR reflect changes in the GBM calibration schedule (affected by launch slip)



SIM/DRM Schedule



06/22/04